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ABSTRACT

This paper presents an analysis of the task characteristics of various academic areas. Multidimensional scaling was performed at the University of Illinois on 168 scholars' judgments about the similarities among 36 academic task areas, and 54 scholars at a small western college judged similarities among 30 areas. The method used in the study was that of sorting the academic areas into categories. Three dimensions were found to be common to both samples: (1) concern with objectivity; (2) concern with application; and (3) concern with life systems. It appears that these dimensions are general to the task of most academic institutions.
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THE CHARACTERISTICS OF THE TASKS
OF ACADEMIC AREAS

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THE CHARACTERISTICS OF THE TASKS OF ACADEMIC AREAS

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Abstract

Multidimensional scaling was performed on scholars' judgments about the similarities among academic task areas. One hundred sixty-eight scholars at the University of Illinois made judgments about 36 areas, and 54 scholars at a small western college judged similarities among 30 areas. The method of sorting (Miller, 1969) was used in collecting data. Three dimensions were common to the solutions of both samples: (1) concern with objectivity and physical objects, (2) concern with application, and (3) concern with life systems. It appears that these dimensions are general to the tasks of most academic institutions.

THE CHARACTERISTICS OF THE TASKS OF ACADEMIC AREAS¹

Anthony Biglan

University of Washington

This paper presents an analysis of the task characteristics of academic areas. In recent years, task characteristics have received increasing attention because of the demonstrable effect of the task on group and organization structure and output (Hackman, 1966; Morris, 1966; O'Brien, 1967; Woodward, 1965). However, task analyses have not been applied to universities or, for that matter, to any organization which has primarily intellectual tasks. Such an analysis is a necessary first step to the examination of relationships between academic tasks and organization structure and output. Moreover, analysis of academic tasks may be of practical value for organizing universities.

The characteristics of academic tasks can be dimensionalized in a variety of ways, depending on the definition of the task and the method of task analysis. In the present study each academic area (e.g., physics, English, psychology) is considered to have a set of problems and methods which constitute the task of the area. This definition of the task is more molar than those found in most small group studies (c.f., Hackman, 1966); it is similar to Woodward's conceptualization of different manufacturing technologies. Also, this definition neglects the fact that most areas have distinct sub-disciplines. It was assumed for the purposes

of this study that the sub-disciplines of each area were more similar to each other than they were to the sub-disciplines of other areas.

Given this definition of the task, how can we get at the "important" characteristics or dimensions of academic tasks? In this study it was assumed that the scholars in the various areas are the best source of information about the characteristics of different areas; whatever dimensions they use in thinking about the academic areas are considered to be important and worth further investigation. Nonmetric multidimensional scaling (Shepard, 1962; Kruskal, 1964a, b) provides an ideal method for determining these dimensions. The method employs subjects' judgments about the similarities (or differences) among a set of stimulus objects. From this ordinal data, a map or array of the stimulus points is developed in a metric multidimensional space which "best fits" the original ordinal data about the similarity of stimuli. In this way the technique provides metric scaling of the stimuli and at the same time indicates the dimensions which underlie subjects' perceptions of them. The technique allows comparison among all academic areas within the same framework but does not restrict the analysis to the oversimplification associated with a single dimension.

At least two dimensions are likely to be used by scholars in thinking about academic areas. First, science and nonscience areas are likely to be distinguished. The science areas differ from nonscience areas in the degree to which their methods and criteria are objective. Scholars in areas such as physics or chemistry seem to be better able to specify what constitutes a solution to a problem or a contribution to the field than

are those in areas such as English or philosophy. A second way in which scholars may perceive the task of an area is in terms of its requirements for practical application. Thus, areas such as engineering and education are likely to be distinguished from areas such as English and chemistry.

Method

Multidimensional scaling of area task characteristics was first performed on data obtained from scholars at the University of Illinois. Since the dimensions obtained in this setting could simply reflect the way areas are organized at large, state-supported universities, the entire scaling was replicated at a small, denominational, liberal arts college in the State of Washington. If the same dimensions are used by scholars at both of these institutions, then we can be more certain that we are getting at characteristics of academic tasks which are general and important. In addition, semantic differential ratings of each area on each of six attributes were obtained from scholars at the small college as an aid to interpreting the scaling results.

Task areas. Thirty-six areas were included in the Illinois scaling. The areas were chosen to include as diverse a sample as possible. The availability of structure and output data was also considered in choosing areas. In the small college replication, all of the areas in which the college offered courses were included for scaling. In addition, four areas which had been used in the Illinois scaling were also used in the replication in order to allow comparison of the results of the two analyses.

Judges. One hundred sixty-eight faculty members at the University of Illinois served as judges of area similarity. They were distributed over the 36 areas of interest with no more than five and no less than three judges in any area. Whenever possible, judges within an area were distributed over academic rank and sub-disciplines. Only six faculty members refused to participate in the study when asked.

All of the approximately seventy faculty members at the small liberal arts college were asked to make judgments about the similarity of academic areas. They were contacted through the Dean of the College, who wrote letters supporting the project. After one telephone follow-up by the Dean's office, 56 faculty members had returned completed judgments of which 54 were usable.

Procedure. Most methods of collecting similarities data require judges to rate or rank the similarity of all pairs of stimuli. In the case of the Illinois scaling, such methods would require $\frac{36(35)}{2}$ or 630 responses from each judge. Since it did not appear that university faculty could be prevailed upon to this extent, a procedure requiring fewer responses of each judge was needed. Such a procedure has been proposed by Miller (1969) and was used in the present study. The method of sorting required judges to put areas into categories on the basis of their similarity. No limit was placed on the number of categories. The judgments of one subject about the similarities among areas may be represented in an N by N matrix whose rows and columns correspond to the academic areas of interest. Ones are placed in the cells of this matrix corresponding to the pairs of areas which were placed in the same

category. Zeroes in cells indicate areas which were not placed in the same category. Summing over all judges' matrices provides a matrix whose cells indicate the number of judges who placed the pair of areas in the same category.

Since this method of collecting similarities data is uncommon, it is important to evaluate its adequacy in comparison with other methods. Rao and Katz (1970) used the method to study the recovery of a known configuration through subject simulation. They obtained a correlation of .81 between the interpoint distances of the known configuration and the interpoint distances of the configuration obtained from the method of sorting. This result compared favorably with the results obtained for more common methods of collecting similarities data. Richards (1971) used real subjects and compared multidimensional scaling results for the sorting method and a more common method of collecting similarities data which involved arraying pairs of stimuli into eight categories corresponding to the degree of similarity of pairs. He obtained five dimensional solutions from each method and compared them using canonical correlations. The canonicals were .98, .96, .90, .60, and .46. On this evidence it appears that the method of sorting is suitable for collecting similarities data to be used in multidimensional scaling.

In collecting data at the University of Illinois, scholars were provided with thirty-six 3 x 5 cards, each of which contained the name of one academic area. They were instructed to sort the cards into categories or piles on the basis of the similarity of the subject matter of each area. Data was typically collected in the scholar's office.

Data from the small college replication were collected through the mails, using essentially the same procedure. In this case, the names of areas were presented on thirty slips of paper and judges were asked to staple together the slips which they placed in the same category. Only one respondent appeared not to have understood these instructions. Upon completing the sorting task, scholars at the small college were asked to rate each area they had judged on the following bipolar adjectives: (1) pure-applied, (2) physical-nonphysical, (3) biological-nonbiological, (4) of interest to me personally-of little or no interest to me personally, (5) traditional-nontraditional, and (6) life science-nonlife science. Forms for these ratings were provided in a separate sealed envelope which judges were asked to leave sealed until they had completed the sorting task.

Results

Scaling of the Illinois Data

Kruskal's (1964b) MDSCAL program (Version 4M) was used to scale the area similarity data obtained from both samples. For the Illinois sample, solutions were obtained in six, five, four, three, and two dimensions. Kruskal's index of goodness of fit between the similarity data and the multidimensional solution is called stress. The stress values for these solutions were .078, .101, .127, .226, and .311, respectively. Each solution was rotated to principal axes in order to aid interpretation.

The three dimensional solution was chosen as the "best" solution, since all three of its dimensions were interpretable and its stress value was .23. Kruskal's (1964a) suggested verbal evaluation for this stress

value is "fair." He adds, however, that "where data values are heavily replicated, this [evaluation] is pessimistic, and larger stress values are acceptable." Since there were 168 replications in the Illinois scaling, Kruskal's comment appears applicable.

The reliability of this configuration was evaluated by splitting the sample of judges into halves, obtaining a separate configuration for each half, and comparing these configurations. The judgments of all scholars who were in the first eighteen areas on an alphabetical list were placed in the first sample and the remaining judgments comprised the second sample. A three-dimensional solution was obtained from the similarity judgments of each sample. The two configurations were compared by correlating the distances among each possible pair of stimuli in one configuration with the corresponding distances in the other configuration. This correlation was .88 ($N=630$). Thus, it appears that in the present circumstances the sorting method of data collection yielded stable results.

There is a second way in which the method of data collection used in the present study may yield unreliable configurations. Stimuli may cluster rather than being evenly dispersed along the dimensions. This is not bad in itself, but with the data collection method used here the distances between points in different clusters may be less reliable than the distances between points in the same cluster. Visual inspection of the final three-dimensional solution from the Illinois sample did reveal clustering of areas. The areas could be grouped into eight clusters on the basis of their interpoint distances and visual

inspection of the configuration. In order to test the reliability of inter-cluster distances, the two three-dimensional configurations described in the preceding paragraph were used. In both configurations, centroids were computed for each of the eight clusters of areas. The distances among the centroids in each configuration were then obtained. If inter-cluster distances are reliable, then there should be a high correlation between corresponding distances in the two configurations. This was, in fact, the case; the correlation was .88 ($N=28$). Thus, although clustering of stimuli occurred, it appears that the inter-cluster distances are reliable.

A third problem associated with the sorting method of data collection is that individual differences in the perceptions of areas cannot be evaluated in the usual ways (c.f., Carroll and Chang, 1969). In the present study it is possible that judges in different areas did not perceive the relationships among academic areas in the same way. This possibility was evaluated in the following way. First, as described above, the sample of areas was split into eight clusters. A separate three-dimensional configuration was computed from the similarity judgments of the faculty in each of these clusters. For each of the eight resulting configurations, interpoint distances among all points in the configuration were computed. Finally, the correlations between the interpoint distances of each solution and every other solution were computed. If these correlations are high and relatively homogeneous, it will suggest that judges in different academic areas perceive the relationship among academic areas in essentially the same way. The

actual correlations range from .61 to .84. The average correlation is .75. No configuration stands out as different from the rest. These results suggest that faculty members in our sample perceive the relationships among academic areas in substantially the same way regardless of their own area.

Figures 1, 2, and 3 present plots of the three-dimensional solution. Each dimension is plotted against the other two so that there are three two-dimensional plots. In Figure 1, dimensions one and two are presented.

Insert Figures 1, 2, and 3 about here

On the first dimension, physical science and engineering areas are at the extreme negative end, while humanities and education areas are at the extreme positive end. Biological areas are on the negative side, though closer to the origin than are the humanities. We thus have "hard" or science-oriented areas at one end of the dimension, social sciences toward the middle, and humanities at the other end of the dimension.

The second dimension (Figures 1 and 2) is a pure-applied dimension. At the extreme positive end are education areas. Accountancy and finance and engineering areas are also at the positive end. On the negative end are physical sciences, mathematics, social sciences, languages, history, and philosophy. Unlike areas at the negative end of this dimension, those at the positive end are concerned with practical application of their subject matter.

The third dimension (Figures 2 and 3) appears to involve a

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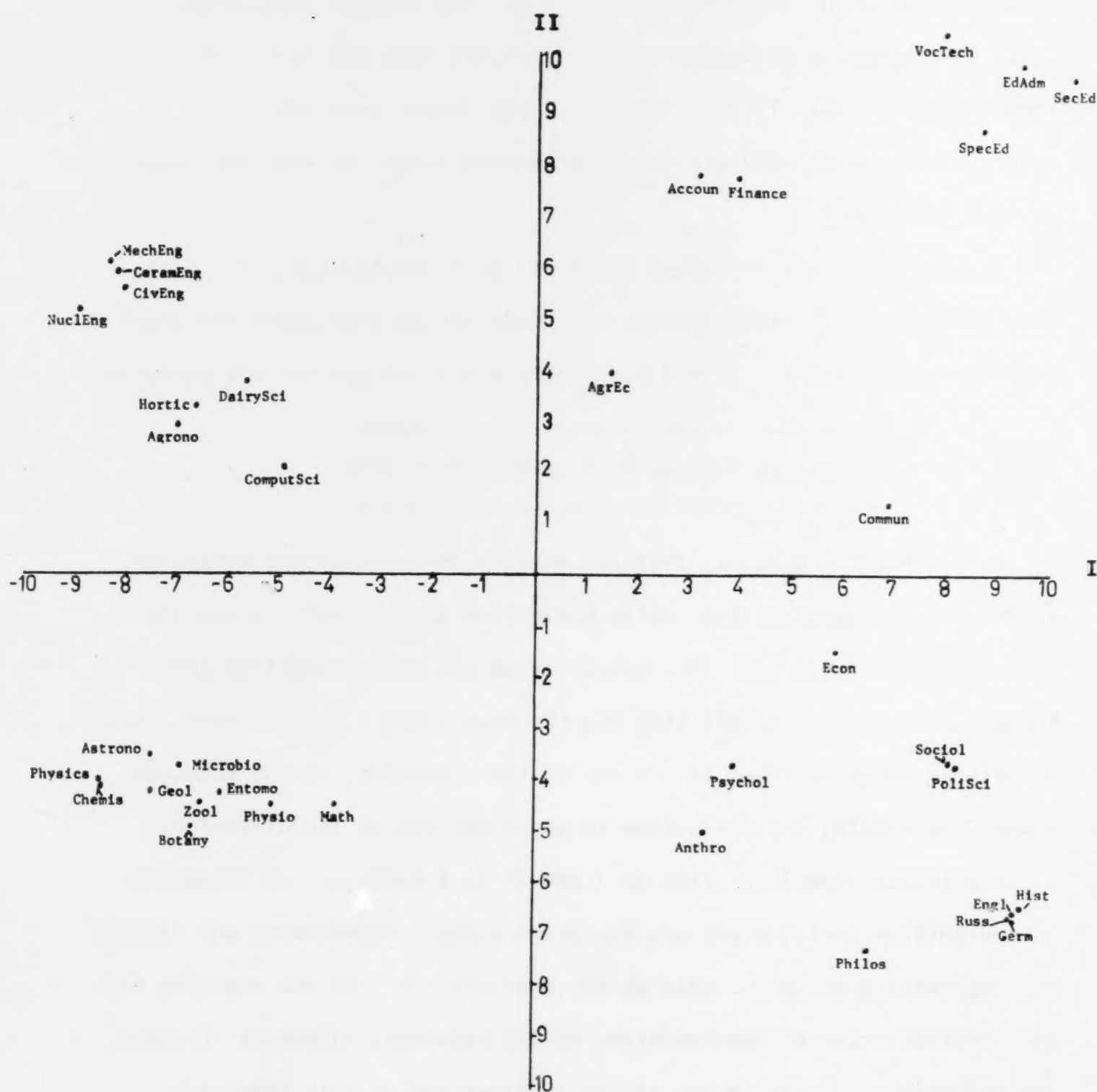


Figure 1

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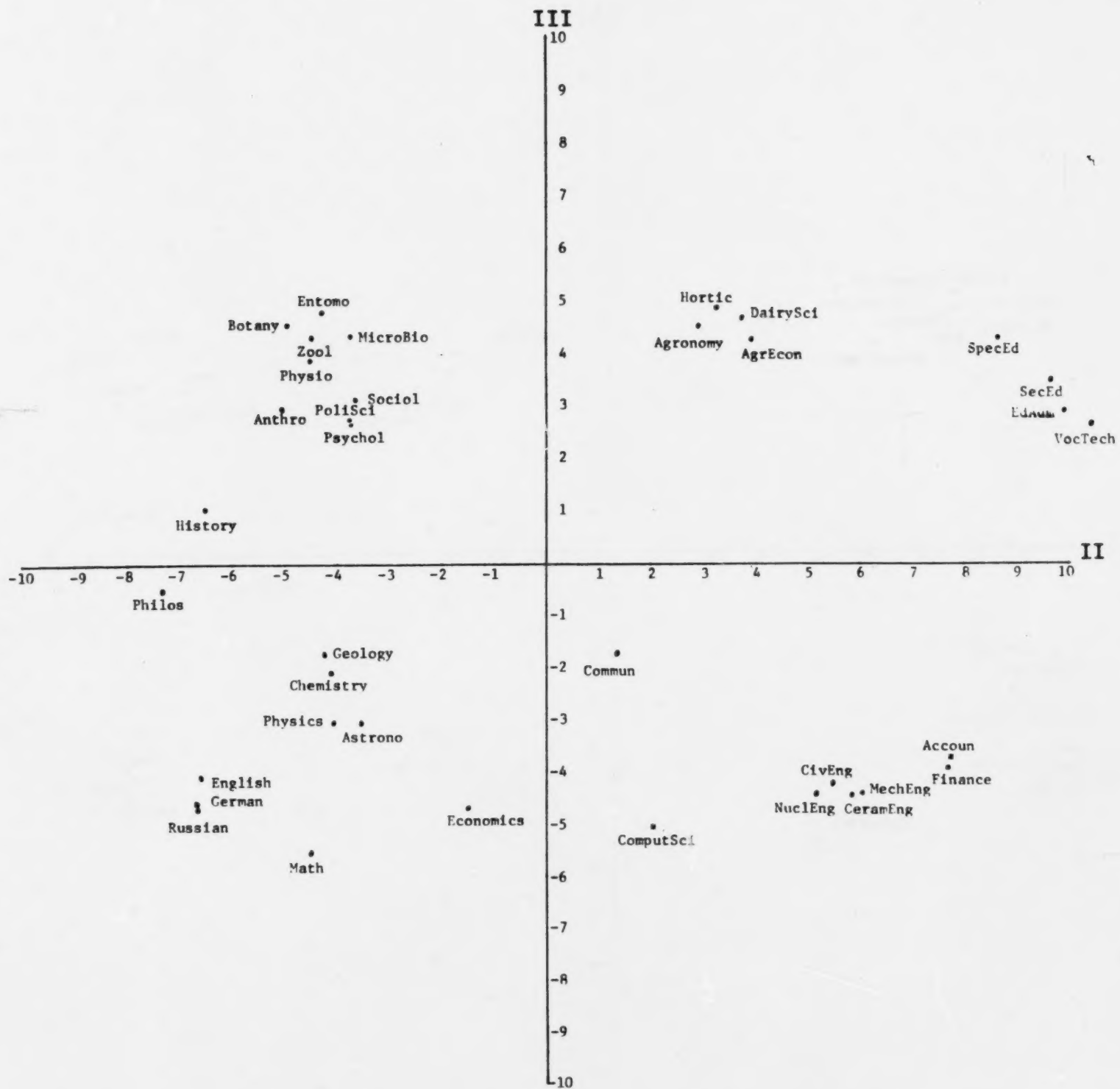


Figure 2

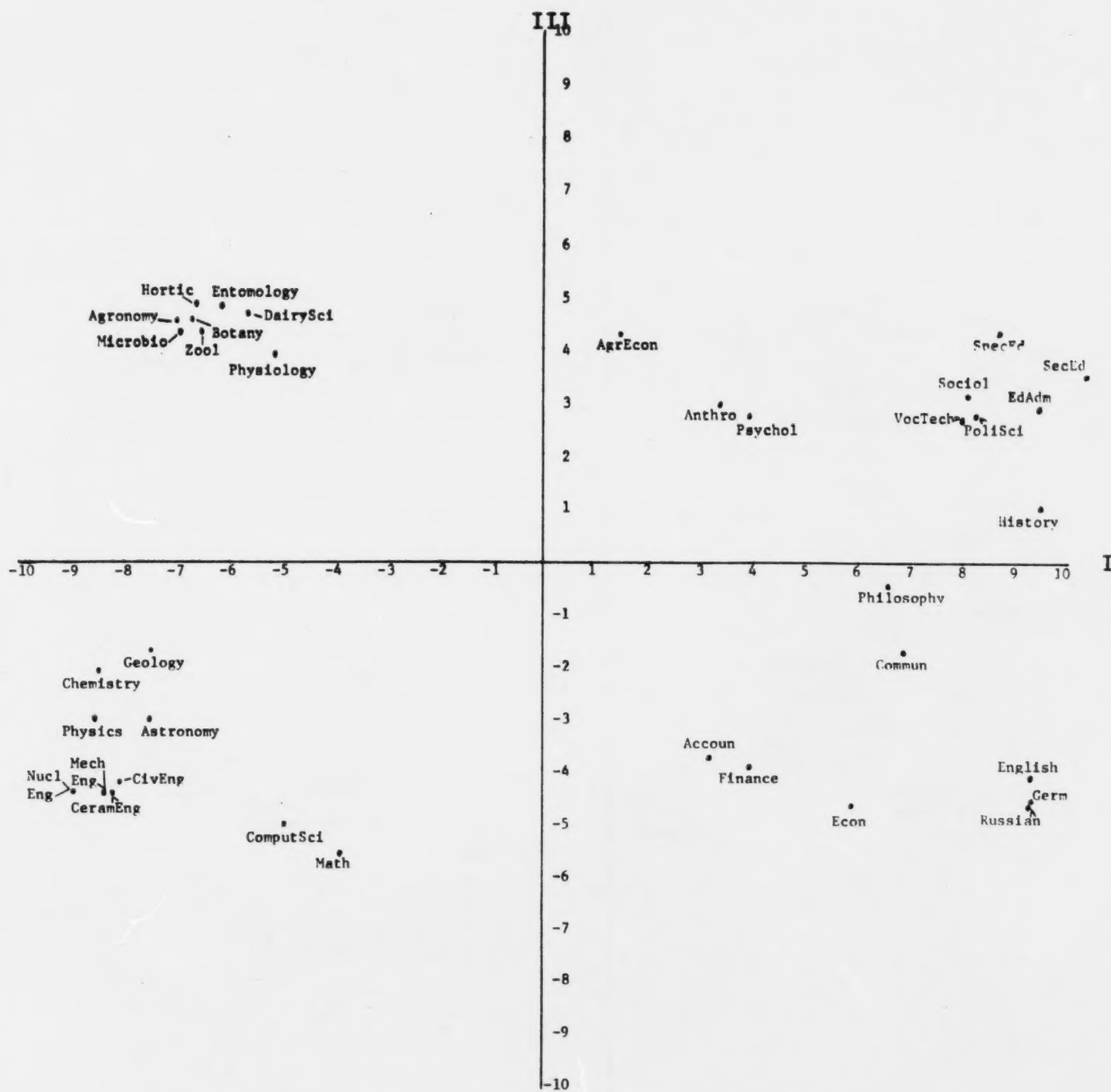


Figure 3

characteristic of the object of study. Areas at the positive end all involve study of living or organic matter, while areas at the negative end do not. Thus, agricultural, biological, social science, and education areas are all high on this dimension. The first two of these groups involve study of all living systems, while the latter two groups are concerned primarily with the study of man. On the negative end of this dimension are all of the areas which do not study living things. These areas do not seem to be widely dispersed, and it appears that the only characteristic they have in common is the absence of biological objects of study.

Scaling of Small College Data

For the small college sample, solutions in six, five, four, and three dimensions were obtained and each was rotated to principal axes to aid interpretation. Stress values for these solutions were .054, .087, .124, and .184 for the six through three-dimensional solutions respectively. The four-dimension solution was chosen as the "best" solution because all four of its dimensions were interpretable and its stress value was "good" (.124) according to Kruskal's suggested evaluations. Plots of this solution are presented in Figures 4, 5, and 6. In each successive figure, the first dimension is plotted against the second, third, and fourth dimensions, respectively.

Insert Figures 4, 5, and 6 about here

We may first ask if any of the dimensions of this solution are

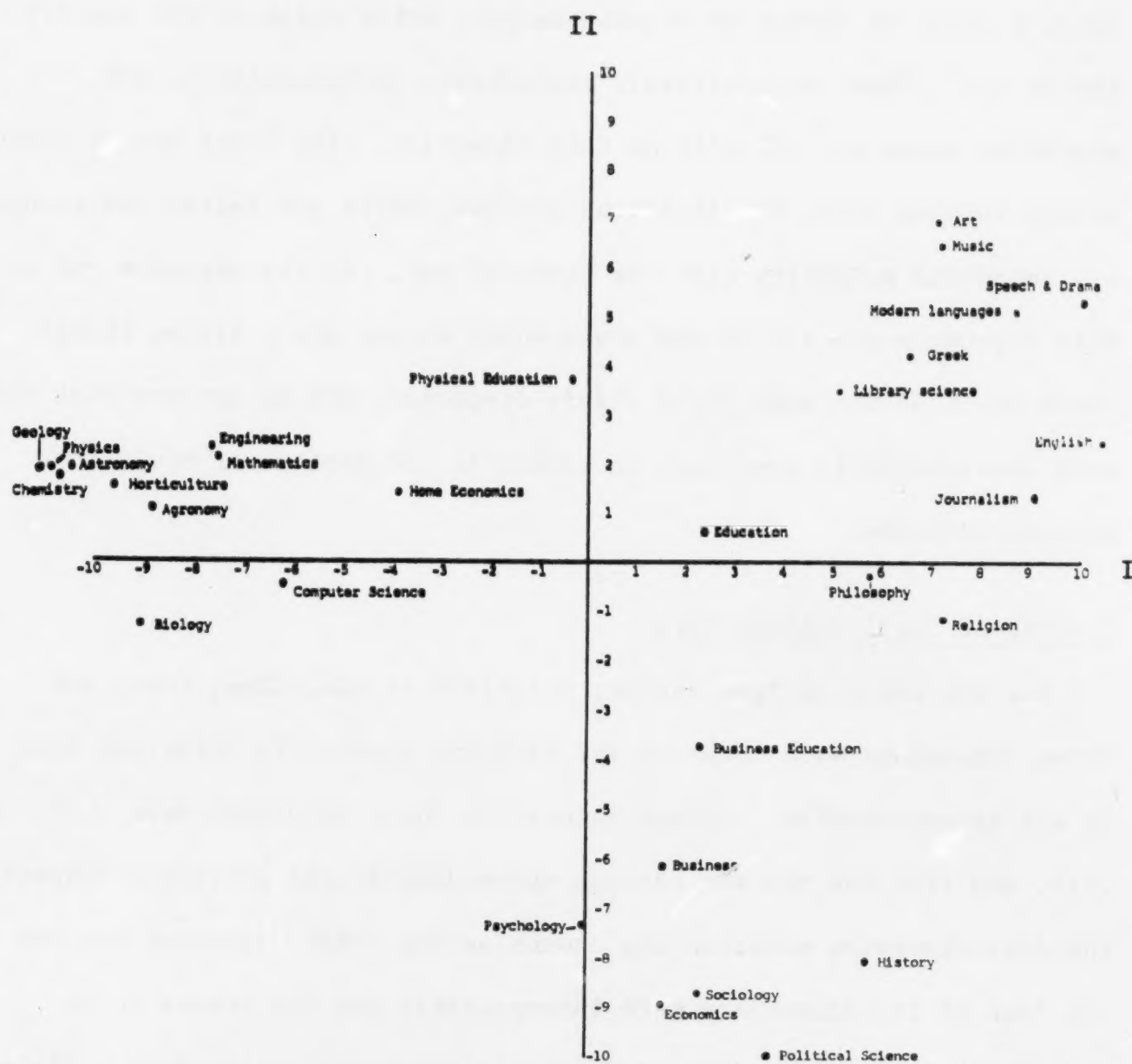


Figure 4

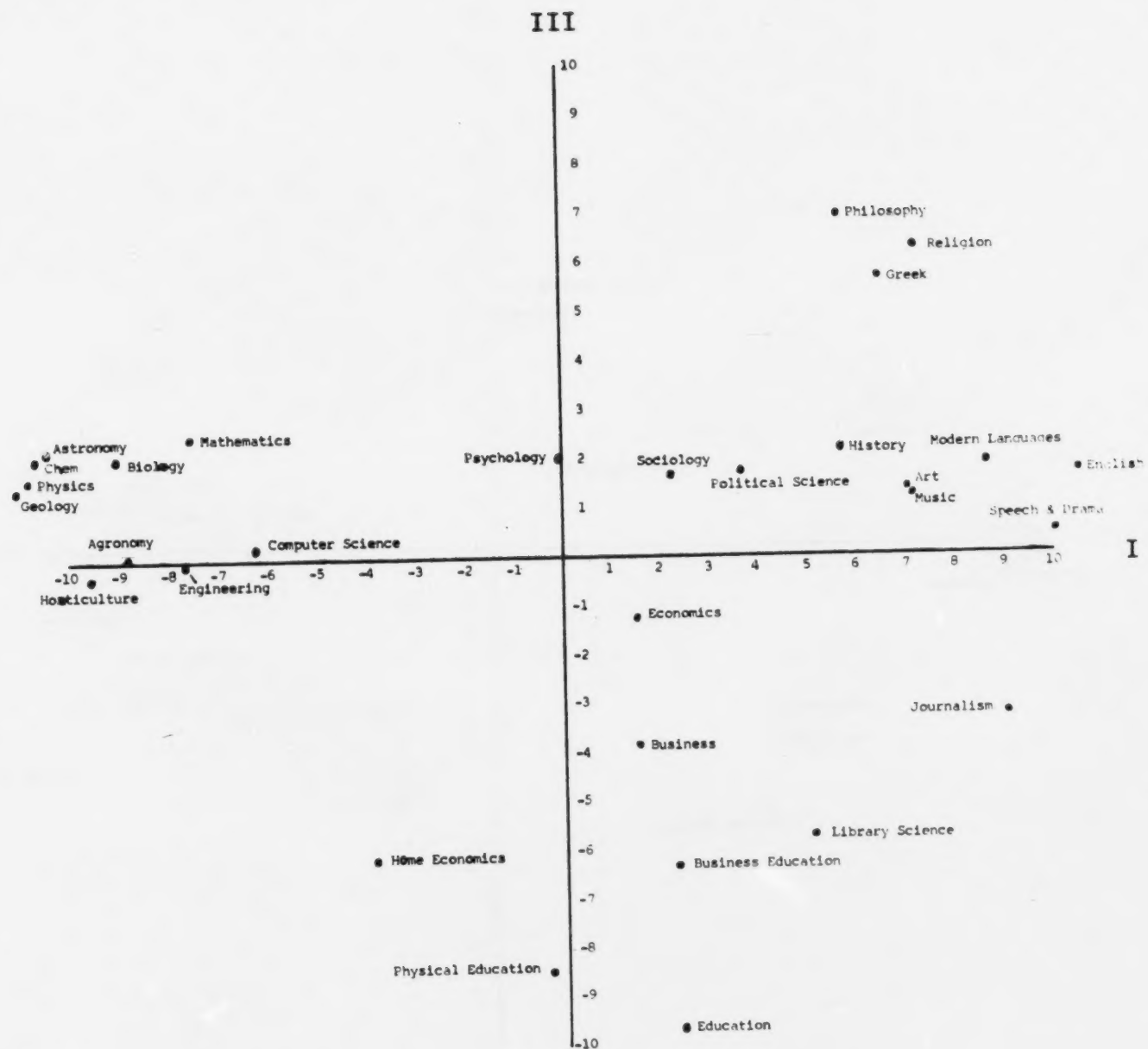


Figure 5

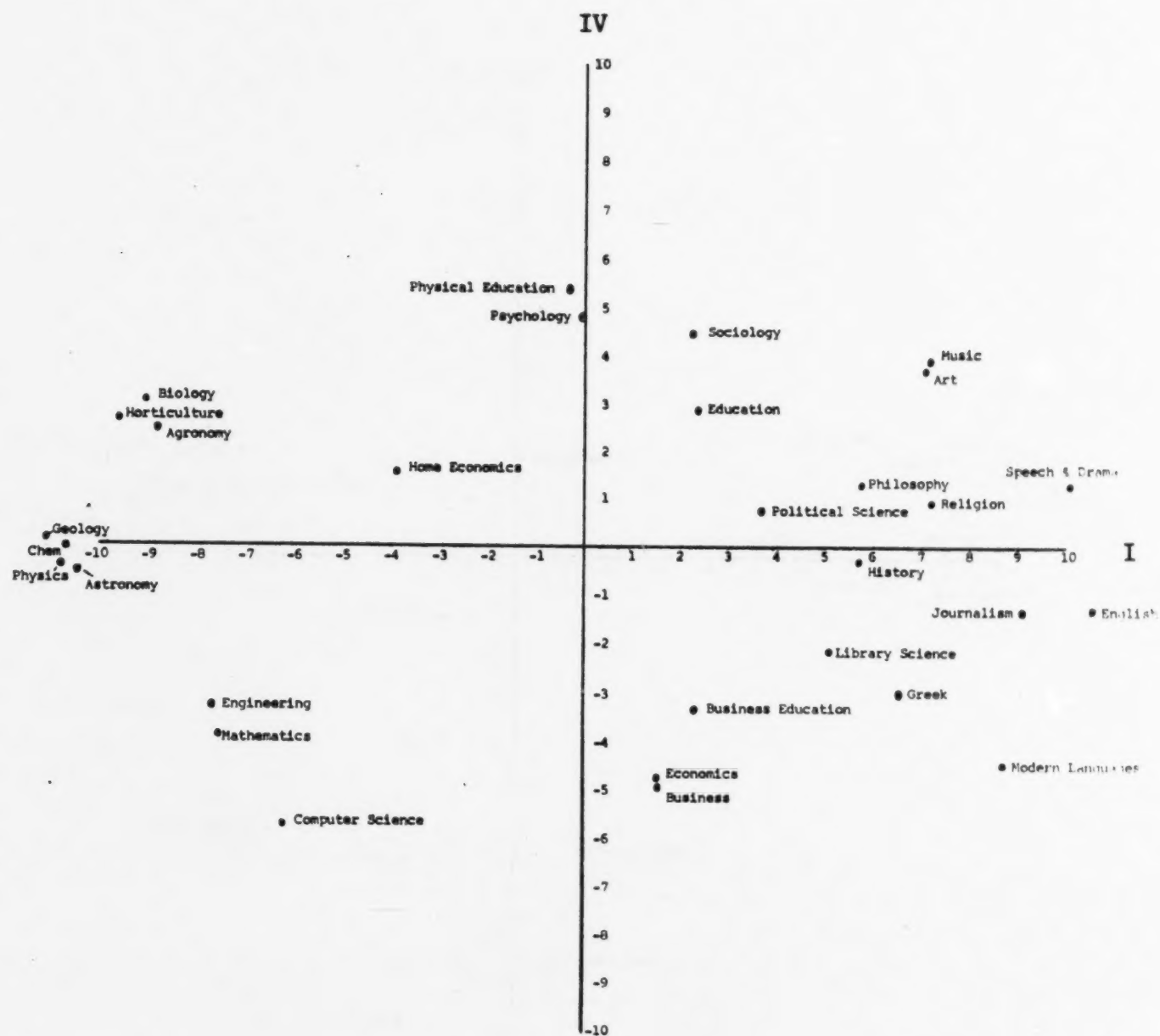


Figure 6

comparable to dimensions of the Illinois three-dimensional solution. Since eighteen areas were common to both solutions, this question can be examined by correlating the positions of these areas on each dimension of the Illinois solution with their position on each dimension of the small college solution. Table 1 presents these correlations. The first dimension of the Illinois solution is virtually identical ($r=.96$) to the first dimension of the small college solution. The dimension distinguishes hard sciences from social sciences and humanities. The second dimension of the Illinois solution is highly correlated ($r = -.81$) with the third dimension of the small college solution. (The negative relationship is due to the inflection of the dimension on one solution and is of no consequence for interpreting the dimensions.) This dimension was interpreted in the Illinois solution as "concern with application." Visual inspection of the third dimension of the small college solution (Figure 5) suggests the same interpretation. On the third Illinois dimension, areas with biological or social objects of study are distinguished from other areas. This dimension is highly related to the fourth dimension of the small college solution ($r = .89$). Thus, it appears that a dimension involving concern of areas with biological or social processes is common to both solutions.

Insert Table 1 about here

The second dimension of the small college solution is not strongly related to any of the Illinois dimensions. Figure 4 shows this dimension

Table 1

Correlations between the Three Dimensions of the Illinois Solution
and the Four Dimensions of the Small College Solution for
Eighteen Areas Common to Both Samples

		Illinois Dimensions		
		I	II	III
Small College Dimensions	I	.96	-.35	-.03
	II	-.47	.16	-.36
	III	-.13	-.81	-.20
	IV	.09	.07	.89

plotted against the first dimension of the small college solution. Art, music, speech and drama, and modern languages are at the positive end of this dimension, while social sciences such as political science, economics, and sociology are at the negative end. All of the areas which are a substantial distance from the origin are commonly found in liberal arts curriculae. Those at the positive end emphasize creative approaches to their subject matter, while those at the negative end emphasize empirical approaches. We may, therefore, tentatively label this dimension creative vs. empirical liberal arts.

It is also useful to inquire about the overall similarity between the Illinois and small college solutions. This problem was examined by computing canonical correlations between the two solutions, for the eighteen areas common to both. Table 2 presents the results of this analysis. The three canonical correlations are .99, .92, and .88, indicating that the two solutions are highly similar.

Insert Table 2 about here

Attribute Analysis

Interpretation of these dimensions becomes more clear when they are related to ratings of each area's attributes. Scholars at the small college rated each area on six bipolar adjectives. These ratings were averaged over all raters and the average for each area was correlated with its position on each of the four dimensions obtained from the replication scaling. There were, thus, six attributes correlated with

Table 2

Canonical Correlations Between Illinois and Small College
Solutions for Eighteen Areas Common to Both

Coefficients for Illinois Dimensions			Coefficients for Small College Dimensions				Canonical Correlation
I	II	III	I	II	III	IV	
1.01	.12	.05	.90	-.15	-.27	.11	.99
-.24	-.42	1.04	-.15	-.14	.23	.93	.92
.09	.98	.11	-.26	.01	-.94	.14	.88

each of four dimensions. Table 3 presents these correlations.

Insert Table 3 about here

Dimension I is correlated (.73) with the physical-nonphysical rating, indicating that the areas arrayed along this dimension differ in the extent to which they study physical objects. Two other attributes, biological-nonbiological and interesting-of no interest, were substantially related to the first dimension, but neither is so highly related to the dimension as to suggest a straightforward interpretation.

Dimension II is not strongly related to any of the attributes. It was suggested above that this dimension involves creative vs. empirical approaches to liberal arts. Dimension II was interpreted above as involving concern with application. This interpretation is supported by the correlation ($r = -.82$) between this dimension and the pure-applied attribute.

Dimension IV distinguishes biological and social fields from other areas. The fourth column of Table 2 shows that both the biological-nonbiological and life science-nonlife science ratings are correlated with dimension IV. However, neither correlation is high enough to justify labeling the dimension according to either attribute. The problem is that neither attribute deals with the extent to which the area is concerned with social processes. Perhaps the best name for this dimension is "concern with life systems."

Table 3

Correlations between Dimensions of Academic Area Scaling
(Small College Sample) and Attribute Ratings
N=30

Attribute	Academic Area Dimensions			
	I	II	III	IV
Pure - applied	-.01	.04	-.82	-.09
Physical - nonphysical	.73	-.26	.40	-.26
Biological - nonbiological	-.52	-.03	-.15	.66
Interesting - of no interest	.50	-.16	.26	.36
Traditional - nontraditional	-.22	-.15	-.51	-.00
Life science - nonlife science	-.44	-.25	-.10	.68

Discussion

Three characteristics of academic tasks are generally perceived by scholars. The most prominent dimension (in terms of the variance it accounts for) distinguishes hard sciences, engineering, and agriculture from social sciences, education, and humanities. The distinction appears to be based on two underlying attributes of the tasks of areas. First, as the small college attribute analysis showed, areas at the negative end of this dimension are more concerned with physical objects of study than are those at the positive end. A second attribute which seems to be related to this dimension is the extent to which areas have objective methods and criteria. Areas at the negative end of this dimension (Figures 1 and 2) have methods for doing research which can be replicated by virtually any competent member of the profession. Areas at the positive end of the dimension lack this kind of objectivity. Rather, these areas call forth creative and individualistic scholarship and involve less reliance on the opinion of others in the field. Unfortunately, this interpretation of the dimension was not developed soon enough to permit inclusion of appropriate attributes in the replication study. Based on these considerations, a good shorthand name for the dimension is "hard-soft." Areas at the negative end of the dimension study harder objects and appear to use more "hard" methods and criteria than do areas at the positive end. The fact that this dimension occurred in both the Illinois and small college solutions suggests that (1) it is a dimension used by most scholars regardless of the kind of institution they are associated with and (2) it does not

result from scholars' reporting the way areas are grouped in their institution.

A second dimension underlying the way scholars view academic task areas is the concern of the area with application to practical problems. Education, engineering, and agricultural areas are distinguished from hard sciences, social sciences, and humanities. The interpretation of this dimension is supported by its correlation with ratings of the areas on a "pure-applied" attribute dimension ($r = -.82$, $N = 30$). This dimension also appears to be used by scholars regardless of the kind of institution they are associated with.

Scholars also distinguish biological and social areas from those which deal with inanimate objects. This dimension also appears to be general to scholars in diverse institutions, since it was used by those at the University of Illinois and at a small liberal arts college. It is labelled "concern with life systems."

The one dimension which was not used by scholars at both institutions distinguished creative and empirical liberal arts areas. It is possible that this dimension did not appear in the Illinois solution because the areas which define the positive end of the dimension (art, music, speech and drama) were not included in the Illinois judgment task. It is also possible that this dimension merely reflects the way that areas are grouped at the liberal arts college where we collected data.

In summary, three dimensions appear to be important for characterizing academic task areas, regardless of the nature of the institution. The dimensions involve (1) the degree of concern with objectivity and

physical objects; (2) degree of concern with application, and (3) degree of concern with life systems. These dimensions are important characteristics of academic task areas in the sense that scholars use them in conceptualizing areas. Whether they are important in the sense that they are associated with the structure and output of the area is examined in a subsequent paper (Biglan, 1971).

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Footnotes

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